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X-ray binaries in the time domain

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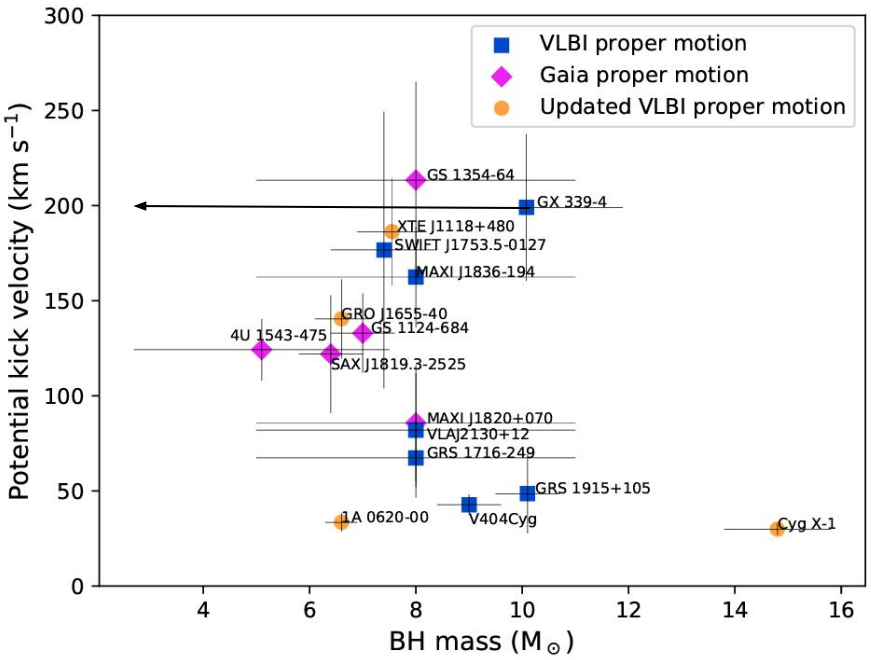
Overview

Important questions addressed by X-ray binary studies

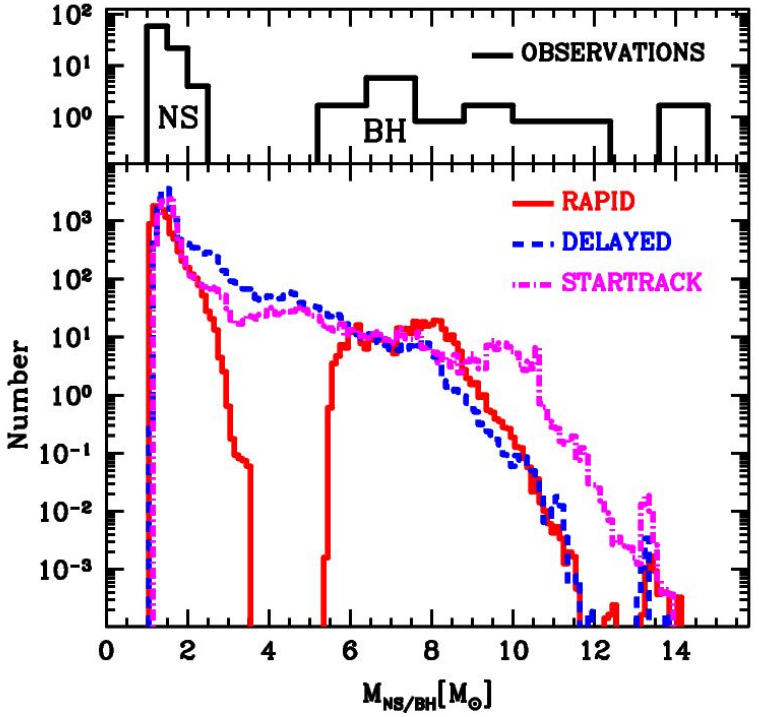
- Supernova explosion mechanism
- Jet production
- GR MHD

Capabilities needed to address these questions

Mass, kick, spin tell about supernova process



Atri et al. 2020



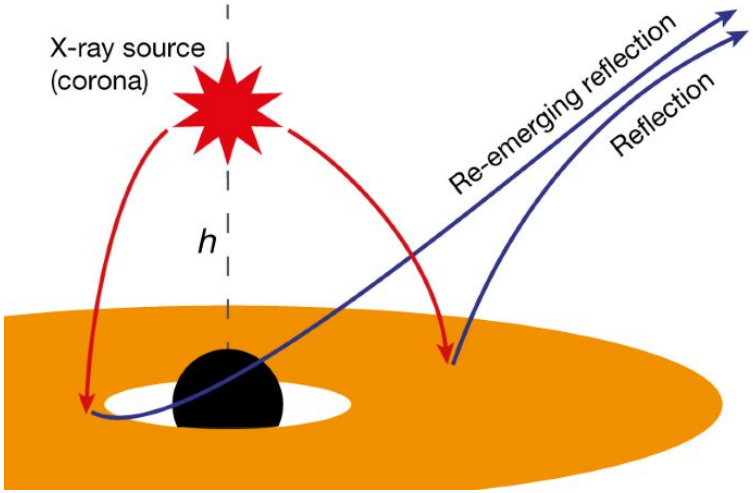
From Belczynski et al. 2012

Improving mass and kick knowledge

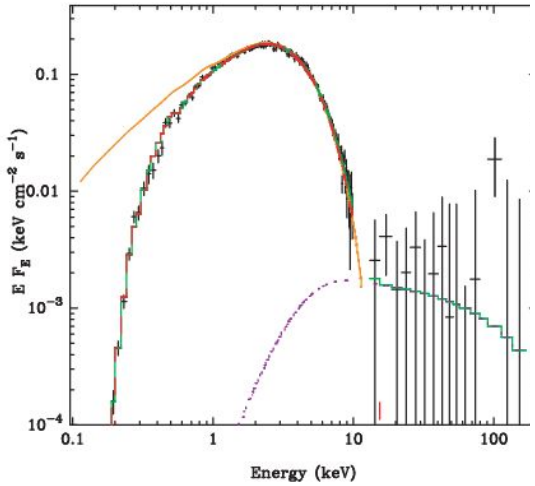
More masses	Sensitive wide-field X-ray monitoring to get more objects Capability of doing optical/IR spectroscopic monitoring on the objects to get the masses (or X-ray timing mass estimates)
More kicks	Sensitive VLBI measurements for proper motions and parallaxes Need to do these while sources are bright

Improving spin measurements

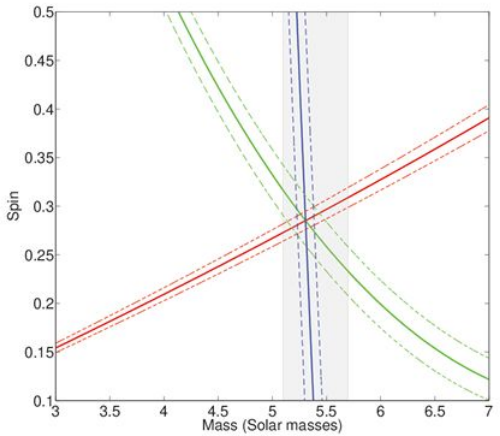
All methods require large collecting area and observations of bright sources!



Wilkins et al. 2020



McClintock et al. 2013



Motta et al. 2014

Reflection lags and QPOs need more collecting area to be applicable to large numbers of sources and to be properly validated

Continuum spin fits just need more measurements of bright X-ray binaries

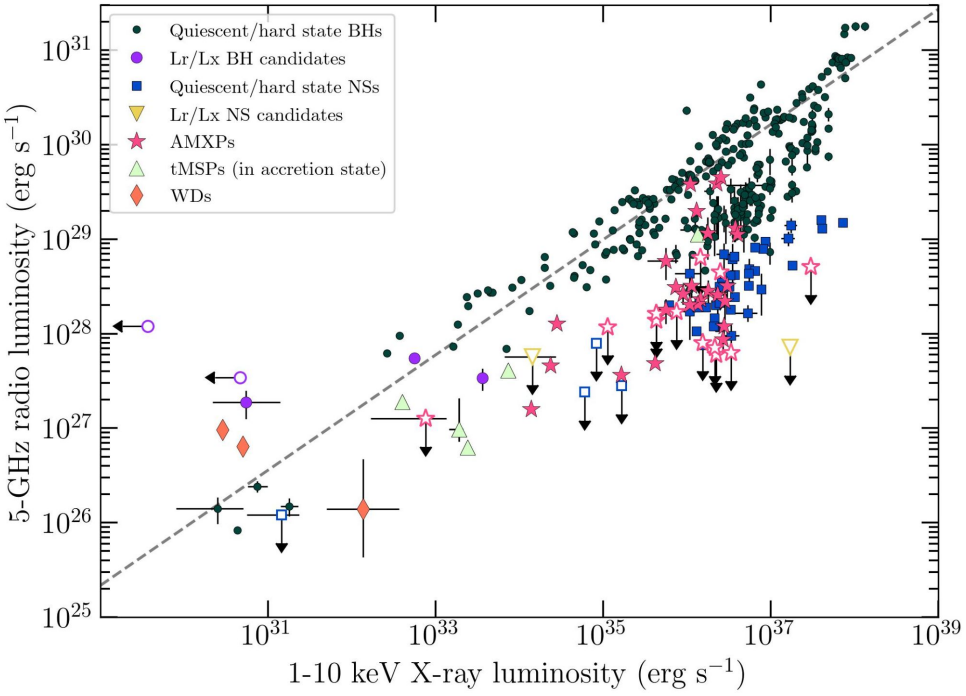
Why high collecting area is so important for rapid variability

$$\frac{S}{N} = \frac{1}{2} I r^2 \left(\frac{T}{\lambda} \right)^{1/2}$$

lambda is frequency width, r is fractional rms amplitude, I is count rate

Thus, exposure time needed to detect a feature scales with the *square* of the collecting area for aperiodic variability

Jets from X-ray binaries



Bahramian website compilation; see Hannikainen et al. 1997; Gallo et al. 2003; Coriat et al. 2011

Can probe disk-jet connection without nuisance parameters

Needs high cadence monitoring in X-ray and radio/mm bands

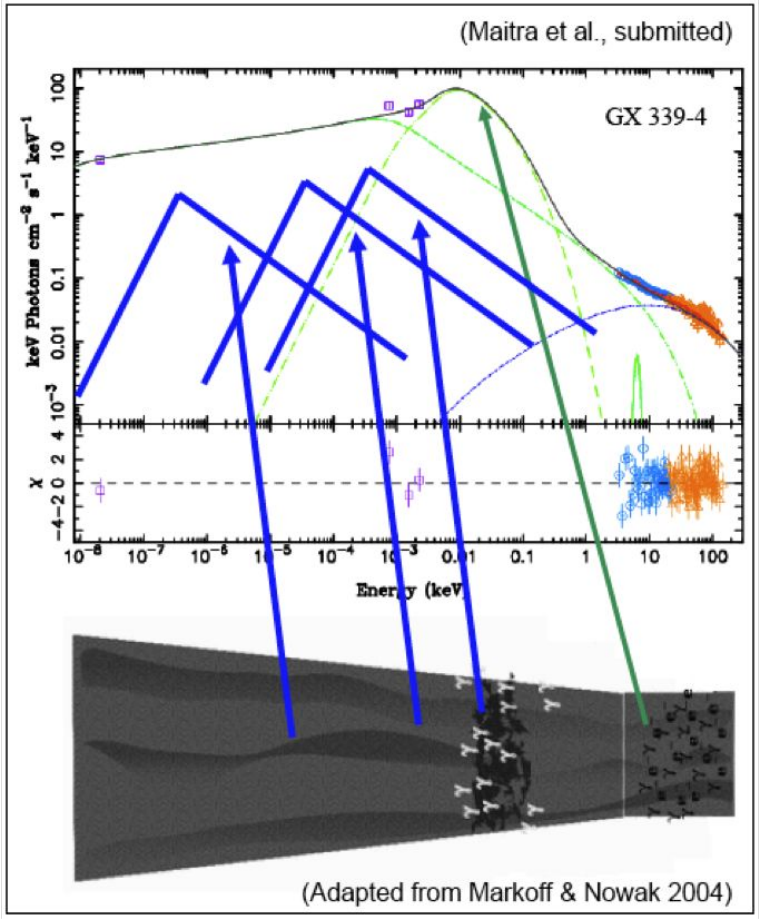
Note: took 14 years to discover steep track!

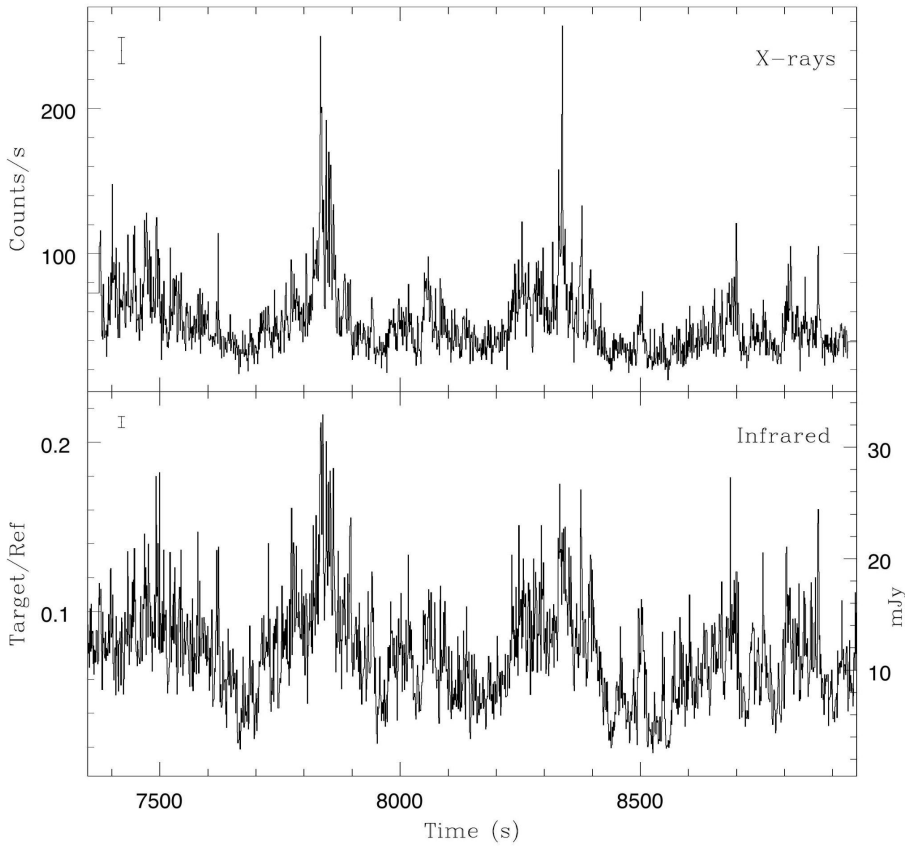
High time resolution jet-disk connection studies

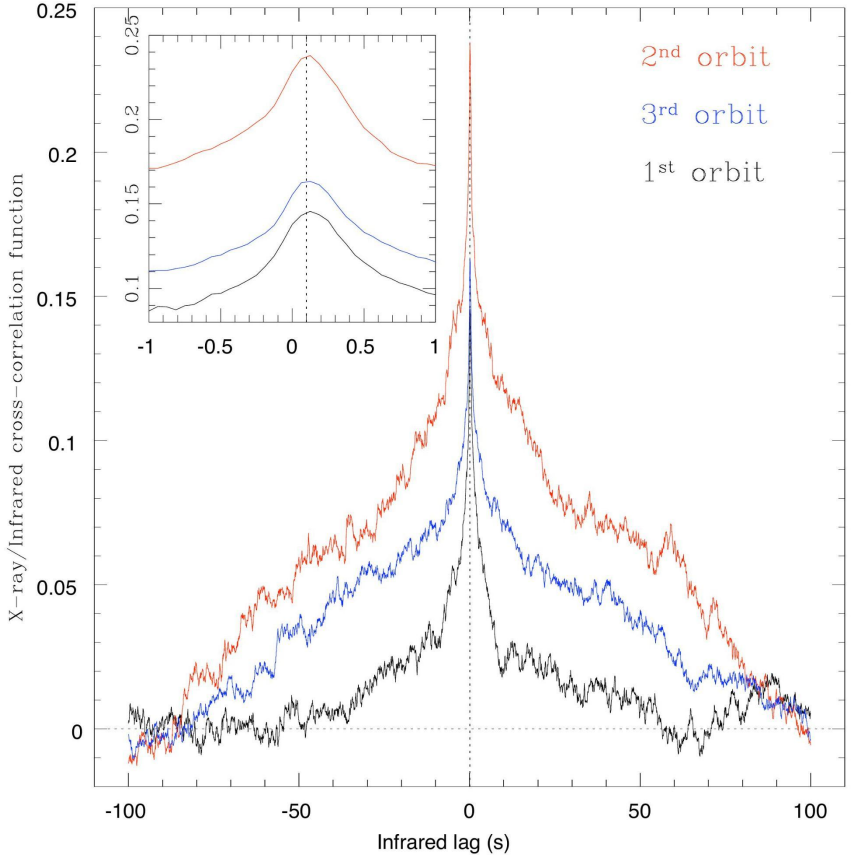
X-ray binary jets cannot be imaged except for the nearest, brightest objects

Size scale for jet cores scales linearly with wavelength, so going to high frequency doesn't help (though sensitive space VLBI could)

Time lag mapping *can* work

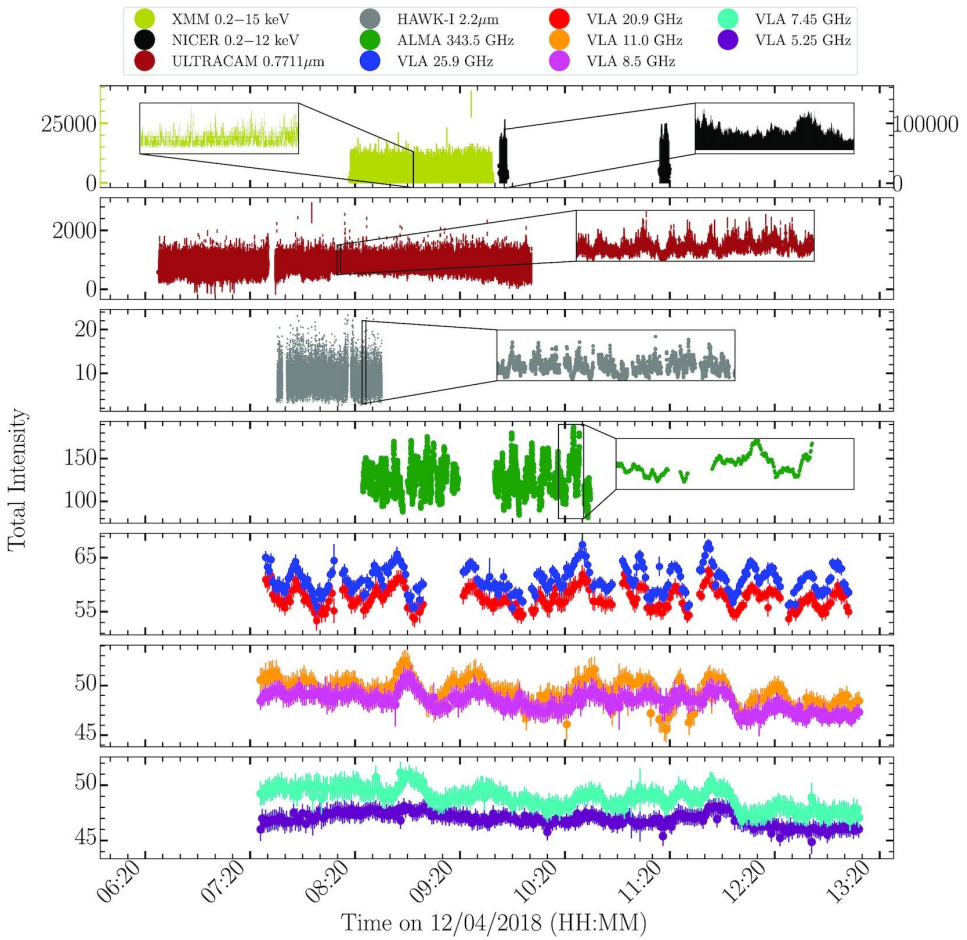




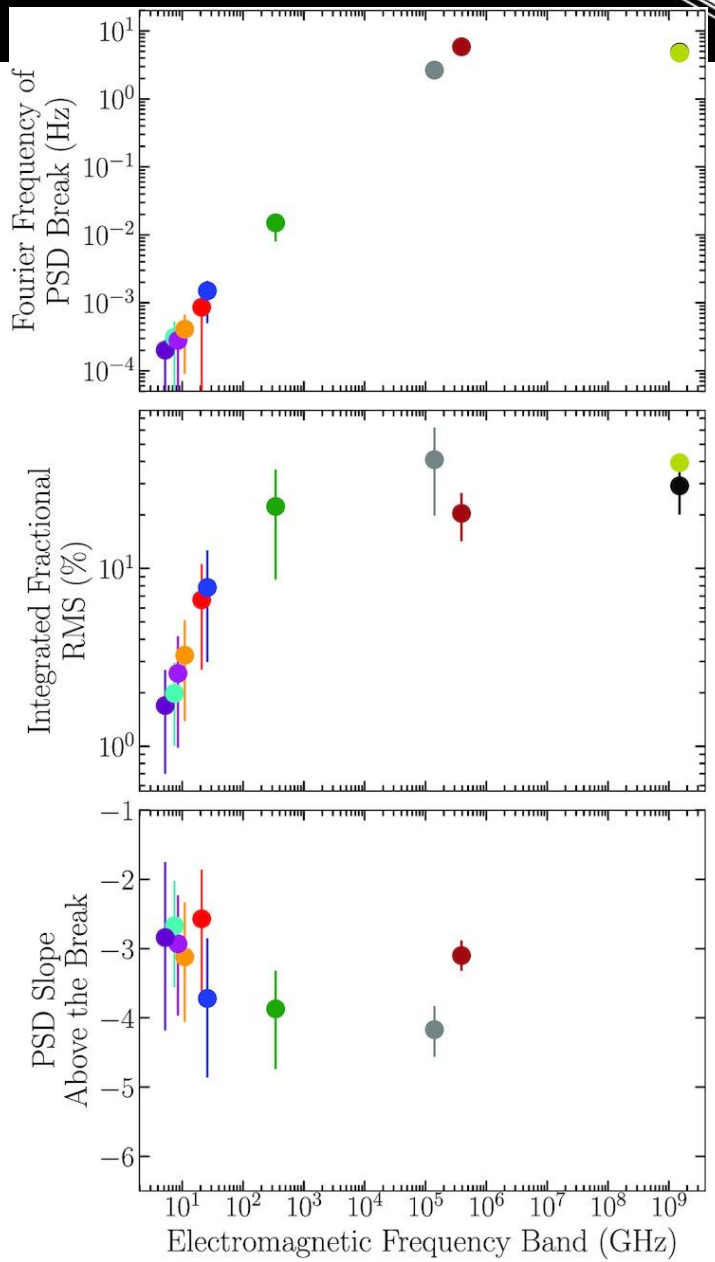


Casella et al. 2010

And at longer wavelengths



Tetarenko et al. 2021



Capabilities needed

1) Wide field monitoring in X-rays
2) High throughput in X-rays – large effective area and ability to handle high count rates, with large field of regard, over wide range of energies
3) High time resolution capabilities, including good absolute timing, including at wavelengths that don't usually prioritize this
4) More joint programs for strictly simultaneous data
5) Subarrays for ALMA
6) Optical/IR spectroscopic monitoring on large telescopes
7) Capability to get parallax distances and proper motions even for highly reddened objects (i.e. sensitive VLBI)